Chapter 1 – Executive Summary

Modern roundabouts are becoming a viable intersection alternative in many United States locations. The acceptable operation of the modern roundabout depends on the location having adequate geometric characteristics (i.e.: deflection, splitter islands) and operating under the yield to the traffic in the circle priority rule. Jurisdictions within the State of Kansas are considering roundabouts in over nine locations. To provide a basis for the understanding of the operation of a modern roundabout in Kansas, a study was performed on the only existing modern roundabout in the State.

This project examined the operation of a roundabout under two comparative scenarios. The roundabout was located in Manhattan, Kansas and was constructed in the fall of 1997. Operation of the roundabout was observed from videotape recorded using a 360^{o} video camera linked to video recording equipment. Traffic data was obtained through viewing the videotapes. Traffic count data was used as input into a computer simulation program called SIDRA (Signalized and Unsignalized Design and Research Aide). Of the evaluative outputs available, six were chosen relating to the operation of the intersection (95% queue length, average delay, maximum approach delay, proportion stopped, maximum proportion stopped, and degree of saturation). The values obtained for each of these measures of effectiveness (MOEs) were statistically tested to determine under what configuration the intersections operated better.

In the first comparison, the operation of the roundabout was measured against two comparable two-way STOP controlled intersections. The values for each of the six MOEs were obtained for the three intersections. The roundabout was found to operate statistically better than the two-way STOP intersections with respect to maximum approach delay, maximum approach stopped and degree of saturation. The roundabout was found to operate statistically worse than the two-way STOP intersections with respect to average delay. Operational conclusions were not able to be made with regard to the MOEs of 95% queue and proportion stopped.

In the second evaluation the operation of the roundabout was evaluated against the pre-roundabout two-way STOP intersection configuration, and two four-way STOP control intersection scenarios. When evaluated for average delay, the roundabout and two-way STOP performed statistically equal to each other, and better than either four-way STOP alternative. Under the remaining five MOEs (95% queue, maximum approach stopped, proportion stopped, maximum proportion stopped, and degree of saturation) the roundabout performed statistically better than the 2 and four-way STOP intersection scenarios.

Traffic conflicts were studied as a predictor of the safety of the three intersections. However, through viewing of over 180 hours of videotapes, only one traffic conflict was observed. Therefore, evaluation of the intersections was not made with regard to traffic conflicts.

Traffic crash records were obtained for thirty-six months before and twenty-nine months after roundabout installation. These crash records were examined to evaluate the change of safety of the intersection when changed to roundabout configuration. Prior to roundabout installation, the intersection experienced an average of 3 crashes per year. Of these crashes, there was an average of 1.33 injury crashes per year. In the twenty-nine months since roundabout installation, there have been no reported traffic crashes.

The Manhattan roundabout installation was found to be a good intersection control/ configuration choice.

This research project has helped to establish that even at relatively low traffic volumes;

roundabout control of an intersection is beneficial. However, caution must be used in taking these results generated from examination of one roundabout site and applying them to all such sites. Much additional study is needed before the engineering community fully understands the operation and safety benefits of roundabouts compared to other intersection control types. This study should be considered a full examination of the Manhattan roundabout, and a first step toward this fuller understanding of roundabout operation.

Section 1.1 - Introduction

Modern roundabouts have a number of operational and physical characteristics that make them unique, and functional as a traffic control device/ intersection configuration. Old style roundabouts have been called traffic circles, rotaries and gyratories. Modern roundabouts have three primary differences from the old style roundabout: yield at entry, deflection and flare *(1)*.

Modern roundabouts operate on the 'yield to circulating traffic' rule. The old method of operation was for drivers in the roundabout to yield to vehicles on the right. This resulted in traffic locking up the roundabout when volumes were heavy. By operating under the 'yield to circulating traffic' rule, vehicles only enter the circulating stream when there is a suitable gap. This allows the modern roundabout to continue to flow even at relatively high traffic volumes.

Modern roundabouts also have properly designed deflection of the entering traffic. The old designs treated roundabouts as weaving sections and were built to facilitate high vehicle entry and circulating speeds. Deflection slows approaching vehicles down to a speed where the safety of the roundabout is greatly enhanced. Operation speeds of modern roundabouts should be kept below 40 kilometers per hour (25 miles per hour) *(2)*.

Table 1 - Roundabout Design Speed and Application

Design Speed (kph)	Design Speed (mph)	Application
19 – 24	12 – 15	Local and collector street intersections
24 – 29	15 – 18	Collector to major arterial roads
29 – 37	18 – 23	Minor to major arterial roads
37 - 40	23 – 25	High speed (80 – 88 kph, 50 – 55 mph) roads including high speed rural intersections

Source: *(2)*

Finally, modern roundabouts can have flared approaches. The widening of the approach road to allow for additional entrance lanes increases the flexibility of the operation for drivers and enhances the capacity of modern roundabouts.

Theoretically the operation of a roundabout is similar to a series of linked 'T' intersections. As such, an approaching driver can check for pedestrian/ bicycle traffic as they approach the intersection, then they have to deal with conflicting traffic from only one direction: the left. Once in the roundabout, the driver continues around until making a right turn to exit the intersection.

"Adequate deflection through roundabouts is the most important factor influencing their safe operation" *(3)*. The deflection through the roundabout is created by both the diameter of the center island, and entrance angle created by the splitter island. The central island should be circular; however, other round shapes (i.e.: ovals) are acceptable. In general, roundabout center islands should have a diameter of 5 to 30 meters (15 – 160 feet) *(3).*

Splitter islands are generally raised median islands that serve many functions. While some older roundabouts were constructed with painted splitter islands, non-raised splitter islands negates many of their advantages. Splitter islands guide vehicles into the circulating roadway of the roundabout, initiating the vehicle's deflection from the approach roadway. As such, they should be designed in conjunction with the vehicles' curved path so that traversing vehicles have a smooth path through the roundabout. The deflection curve establishes the horizontal path of a vehicle going through the roundabout and defines the design speed of the roundabout. Therefore, the tighter the deflection curve, the slower the design speed of the roundabout *(2).*

Splitter islands also serve to prevent wrong way movements. They create physical barriers whereby a vehicle wishing to traverse the roundabout the wrong way would have to travel over or through the splitter island.

The approach ends of splitter islands can provide a physical narrowing of the approach roadway prior to the flare area. This narrowing of the approach road tends to slow vehicle approach speeds and alerts drivers to the upcoming roundabout. Splitter islands have a tendency to change driver expectancy as they approach the roundabout.

Finally,

> "On arterial road roundabouts, the splitter island should be of sufficient size to shelter a pedestrian (at least 2.4 meters wide) and be a reasonable target to be seen by approaching traffic. A minimum total area of 8 to 10 m^2 should be provided on arterial road approaches" *(3).*

Therefore, the splitter islands also act as pedestrian refuge islands. This allows a pedestrian to cross one direction of traffic, reach the splitter island, then cross the other. Separation of the crossing movement enhances pedestrian safety at roundabouts. The use of splitter islands for pedestrian refuge requires that they be designed to meet all applicable (including the Americans with Disabilities Act) requirements relating to pedestrian activity.

Modern roundabouts often have beautified center islands. Both the Oregon *(4)* and Maryland *(1)* State guides for roundabouts provide directions on how to safely landscape the center island so as not to compromise visibility. The landscaping of the center island allows the roundabout to function as an urban design element.

When trucks need to be accommodated at a roundabout, the design usually includes a truck apron. This is a part of the center island that is not fully raised above the circulating roadway pavement. Rather it is raised 5 to 10 cm (2 – 4 in). Truck aprons are most often constructed of a contrasting material to help differentiate them from the circulating roadway. The purpose of a truck apron is to provide an area where the rear wheels of a large vehicle can be accommodated while keeping the central island small (and therefore maintaining the needed travel path deflection).

The Australian guide to traffic engineering practice for roundabouts *(3)* lists a number of methods of intersection control as well as where roundabouts are appropriate and inappropriate.

"Roundabouts may be appropriate in the following situations:

- At intersections where traffic volumes on the intersecting roads are such that:
    - 'Stop" or 'Give Way' signs or the 'T' junction rule result in unacceptable delays for the minor road traffic. In these situations, roundabouts would decrease delays to minor road traffic, but increase delays to the major

road traffic.

- Traffic signals would result in greater delays than a roundabout. It should be noted that in many situations roundabouts provide a similar capacity to signals, but may operate with lower delays and better safety, particularly in off-peak periods.

- At intersections where there are high proportions of right (left)-turning traffic….
- At intersections with more than four legs….
- At cross intersections of local and/or collector roads where a disproportionately high number of accidents occur involving either crossing traffic or turning movements….
- At rural cross intersections (including those in high speed areas) at which there is an accident problem involving cross traffic….
- At intersections of arterial roads in outer urban areas where traffic speeds are high and right (left) turning traffic flows are high….
- At ‘T’ or cross intersections where the major traffic route turns through a right angle….
- Where major roads intersect at ‘Y’ or ‘T’ junctions….
- At locations where traffic growth is expected to be high and where future traffic patterns are uncertain or changeable.
- At intersections of local roads where it is desirable not to give priority to either road” *(3).*

Parenthetical notation added by author to apply to driving on right circumstances.

The manual then proceeds to list a number of locations where roundabouts may not be an appropriate traffic control.

“Roundabouts may be inappropriate in the following situations:

- Where a satisfactory geometric design cannot be provided due to insufficient space or unfavorable topography or unacceptably high cost of construction….
- Where traffic flows are unbalanced with high volumes on one or more approaches….
- Where a major road intersects a minor road and a roundabout would result in unacceptable delay to the major road….
- Where there is considerable pedestrian activity and due to high traffic volumes it would be difficult for pedestrians to cross the road….
- At an isolated intersection in a network of linked traffic signals….
- Where peak period reversible lanes may be required.
- Where large combination vehicles or over-dimensional vehicles frequently use the intersection and insufficient space is available to provide for the required geometric layout.
- Where traffic flows leaving the roundabout would be interrupted by a downstream traffic control which could result in queuing back into the roundabout.” *(3).*